

Chronology & Brief Results of Space Exploration of Venus

Spacecraft	Launch	Encounter	Geographical coordinates of Landing or Encounter	Main Results
Venera I flyby	12 Feb 1961	—	—	First spacecraft launched at interplanetary trajectory from geocentric orbit; closest approach: 100000 km.
Mariner 2 flyby	27 Aug 1962	14 Dec 1962	—	Closest approach: 34 833 km; plasma and magnet field measurements; local radio-emission in cm-interval measurements.
Venera 2 flyby	12 Nov 1965	—	—	Flyby at the closest approach of 24000 km.
Venera 3 flyby	16 Nov 1965	1 Mar 1966	—	First hard landing.
Venera 4 automatic interplanetary station (bus) with entry probe	12 Jun 1967	18 Oct 1967	19° N; 38° (landing)	Measurements of lower atmospheric chemical composition; direct P-T measurements along the descent; wind velocity measurement; hydrogen "corona" in upper atmosphere was discovered.
Mariner 5 flyby	14 Jun 1967	19 Oct 1967	37° N; 125° (encounter) 32.4° N; 310° (parting)	Radio emission measurements resulted in first data on the structure and density of Venus' atmosphere. Indirect estimates of atmospheric chemical composition.
Venera 5 bus with entry probe	5 Jan 1969	16 May 1969	3° S; 1 8° (landing)	Affirmation of dominantly carbon dioxide (97%) atmospheric composition; determination of N ₂ and H ₂ O content in atmosphere below cloud base.
Venera 6a reserve of Venera 5	10 Jan 1969	17 May 1969	5° S; 23° (landing)	See Venera 5.

Venera 7 bus with lander	17 Aug 1970	15 Dec 1970	5° S; 351° (soft landing)	Direct measurement of surface temperature (747 ±20 K) and surface pressure estimates (92.3 ± 15 atm) based on accurate data on atmospheric temperature and rate of lander descent.
Mariner 10 flyby	3 Nov 1973	5 Feb 1974	0.9° N; 69.5° (encounter) 56.3° S; 236.4° (parting)	Cloud dynamics investigation; cloud deck measurements by radio emission and UV photometers.
Venera 8 bus with lander	27 Mar 1972	22 Jul 1972	10° S; 335° (soft landing)	Measurements on the insolation in lower atmosphere and at the planetary surface; measurements of optical properties and other affinities of clouds; direct determination of pressure at the planetary surface; measurements of radioactive element content in the Venus soil and certain physical properties.
Venera 9 orbiter with lander	8 Jun 1975	22 Oct 1975	31.7° N; 290.8° (soft landing)	Orbiter was placed into orbit around Venus apoapsis of 112200 km, periapsis of 1560 km, rotation period of 48 h 18', orbit inclination 34°10'. Heat asymmetry of cloud deck was revealed, physical properties of atmosphere and clouds were investigated. First TV images of landing site areas obtained from lander, measurements of soil density and wind velocity at the planetary surface.
Venera 10 orbiter with lander	14 Jun 1975	25 Oct 1975	16° N; 290.8° (soft landing)	Orbiter was placed into orbit around Venus with apoapsis of 113 200 km, periapsis of 1620 km, rotation period of 49 h 23', orbit inclination 29°30'. For the first time two bistatic radar profiles were obtained; other results are of the same kind as Venera 9

Pioneer Venus orbiter	20 May 1978	4 Dec 1978	—	Orbiter was placed into orbit around Venus with apoapsis of 66000 km, periapsis 200 km, rotation period of 24 h, orbit inclination 105°; radar mapping of 90% of planetary surface was carried out with areal resolution of 30 km and altitude resolution of 700 m with 200 m accuracy. Gravimetric mapping.
Pioneer Venus bus with 4 hard landers	8 Aug 1978	4 Dec 1978 (encounter)	Night Probe* 28.7° S; 56.7° North Probe* 59.3° N; 4.8° Day Probe* 81.7° S; 317° Large Probe 4.4° N; 304° bus 37.9° S; 290.9° (encounter)	Direct measurements of neutral and ionic composition of upper atmosphere; cryosphere was discovered; measurements of heat emission in atmosphere; the absence of intrinsic magnetic field was proved; determination of microcomponent content in Venus' atmosphere and the isotopic composition; investigation of chemical composition and physical properties of cloud particles.
Vener 11 flyby with lander	9 Sep 1978	25 Dec 1978	14° S; 299° (soft landing)	Numerous determinations of chemical composition and physical properties of atmosphere and clouds; x-ray fluorescent analysis of cloud particle chemical composition; chemical and isotope composition of microcomponents; electric charges in low atmosphere are registered.
Venera 12 reserve of Venera 11	14 Sep 1978	21 Dec 1978	7° S; 294° (soft landing)	See Venera 11.

Venera 13 flyby with lander	30 Oct 1981	1 Mar 1982	7.5° S; 303.5° (soft landing)	Color TV panorama of landing was transmitted. Elemental chemical composition of surface rock at the landing site was determined using the x-ray fluorescent analysis; attempt of microseismic event measurements was undertaken.
Venera 14 reserve of Venera 13	4 Nov 1981	5 Mar 1982	13° S; 310°	See Venera 13.
Venera 15 orbiter Venera 16 orbiter	2 Jun 1983 7 Jun 1983	10 Oct 1983 14 Oct 1983	— —	Orbiters were placed into orbit around Venus with apoapsis of 66,000 km and periapsis of 1000 km, rotation period of 24 h, orbit inclination 92° 30'. Radar mapping of 25% of the planetary surface with areal resolution of 1-2 km, and altitude resolution of 30 m. Geologic map and photomap of 1:5000000 were produced, orbiters transmitted the information up to 10 Jul 1984.
Vega I flyby with lander	15 Dec 1984	11 Jun 1984	8.1° N; 176.7°	Experiment with balloons drifted within the cloud layer (h = 54 km) along a distance of 11000 km; new direct analysis of cloud chemical composition was carried out: a complete vertical temperature profile of lower atmosphere (0-63 km) with ±1° K accuracy was produced; new x ray fluorescent analysis of soil elemental composition was made at Vega 2 landing site.
Vega 2 reserve of Vega 1	21 Dec 1984	15 Jun 1984	7.2° S; 179.4° (soft landing)	

Magellan	4 May 1989	10 Aug 1990	—	SAR radar mapped 98% of the planet at better than 300 meter resolution and collected altimetry. Stereo coverage of about 20% of planet. Improved comprehensive gravity field measurements in Cycles 4-5 mapped 95% of planet; plunged into atmosphere Oct 11, 1994, collecting data of the behavior of molecules in Venus' atmosphere and performance of spacecraft during descent.
Galileo	18 Oct 1989	9 Feb 1990	—	Spectroscopic and radioactivity analysis of Venus's clouds. Photographs of middle atmosphere clouds. ¹

Source: Table A, pp. 2-6 in A. T. Basilevsky, O. V. Nikolayeva, and V. P. Volkov, "Introduction," pp. 1-7 in Barsukov et al, *op. cit.* One column has been omitted and data added for Magellan and Galileo. Source of Magellan data is "Magellan Summary Sheet" <http://www.jpl.nasa.gov/magellan/fact1.html>; and of Galileo data is "Planetary Science Spacecraft" <http://caboose.com/nineplanets/spacecraft.html> and "Galileo Home Page" <http://www-a.jpl.nasa.gov/galileo/fact>, "NSSDC Photo Gallery: Venus" http://nssdc.gsfc.nasa.gov/photo_gallery/photogallery-venus.html

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¹ According to "Galileo: Amazing Facts," <http://www.jpl.nasa.gov/galileo/fact/>, Galileo "became the first spacecraft to see the surface of Venus without the use of radar. On February 10, 1989, it observed the oven-hot surface with its near-infrared camera, observing numerous mountain ranges and valleys through Venus' thick atmosphere and clouds." I have seen no other reference to this and cannot find the pictures that supposedly were taken.